Acta Neurochir (Wien) (2006) 148: 965–969
DOI 10.1007/s00701-006-0816-3

Acta Neurochirurgica
Printed in Austria

Neurosurgical Technique

The midline suboccipital subtonsillar approach to the hypoglossal canal: surgical anatomy and clinical application

M. Tatagiba, A. Koerbel, and **F. Roser**

Department of Neurosurgery, University of Tübingen, Tübingen, Germany

Received October 26, 2005; accepted May 4, 2006; published online July 5, 2006

Summary

Primary lesions of the hypoglossal canal, such as hypoglossal schwannomas, are rare. No consensus exists with regard to the surgical approach of choice for treatment of these lesions. Usually, lateral transcondylar approaches have been used. The authors describe the surgical anatomy of the midline subtonsillar approach to the hypoglossal canal. This approach includes a midline suboccipital craniotomy, dorsal opening of the foramen magnum and elevation of ipsilateral cerebellar tonsil to expose the hypoglossal nerve and its canal. The midline subtonsillar approach permits a straight primary intradural view to the hypoglossal canal. There is no necessity of condylar resections. The surgical anatomy of the subtonsillar approach is described and illustrated by an example of a case.

Keywords: Hypoglossal canal; schwannoma; foramen magnum; approach; skull base; posterior fossa.

Introduction

Intracranial schwannomas arising from motor cranial nerves are uncommon and frequently associated with neurofibromatosis [2, 21]. Lesions involving the hypoglossal canal, such as hypoglossal nerve (CN XII) schwannomas, are rare [2, 4, 10, 18, 22, 23, 26]. In approximately 30% of the usually intracranially originating hypoglossal schwannomas, tumour growth is directed into the extracranial space and show a dumbbell shape [10, 26] or it may be completely extracranial [1]. Different approaches have been described to manage hypoglossal schwannomas [2, 4, 8, 10, 18, 22, 23, 26]. However, transcondylar approaches have been preferentially used [8, 23, 24, 26].

We describe the anatomy of the suboccipital midline subtonsillar approach (STA). The STA provides an excellent surgical view of the entire intradural segment of the hypoglossal nerve, from the brainstem up to the hypoglossal canal. Because hypoglossal schwannomas usually produces enlargement of the hypoglossal canal the straight angle of view given by the STA allows the surgeon to follow the tumour along to its intracanalicular portion up to the extracranial spaces. An example of a large hypoglossal schwannoma is shown to illustrate the technical details of the STA.

Anatomy

The hypoglossal nerve consists intracranially of three portions: the intramedullary, the cisternal and the canalicular segment. The intramedullary segment arises from the hypoglossal nucleus, in a paramedian location in the floor of the forth ventricle, and exits at the preolivary nucleus [28]. At this point, the cisternal segment emerges from 12 to 16 hypoglossal nerve rootlets into three to six bundles [15]. These bundles, which run in the premedullary cistern in an anterolateral direction, are located between the postero-inferior cerebellar artery (PICA) posteriorly and the vertebral artery anteriorly [28] (Fig. 1). These rootlets pierce the dura of the canal in two separated apertures in 76.57% of cases, in one aperture in 21.87% and rarely in three or more apertures [3]. The distance between these apertures may vary from 0.6 mm to 8.7 mm [3]. The hypoglossal canal extends from the posterior fossa to the nasopharyngeal carotid space. It is formed and surrounded by several bony structures, as follows: the occipital condyles inferiorly, the jugular foramen and the jugular process of the occipital bone laterally, and the sphenoid part of the clivus superomedially

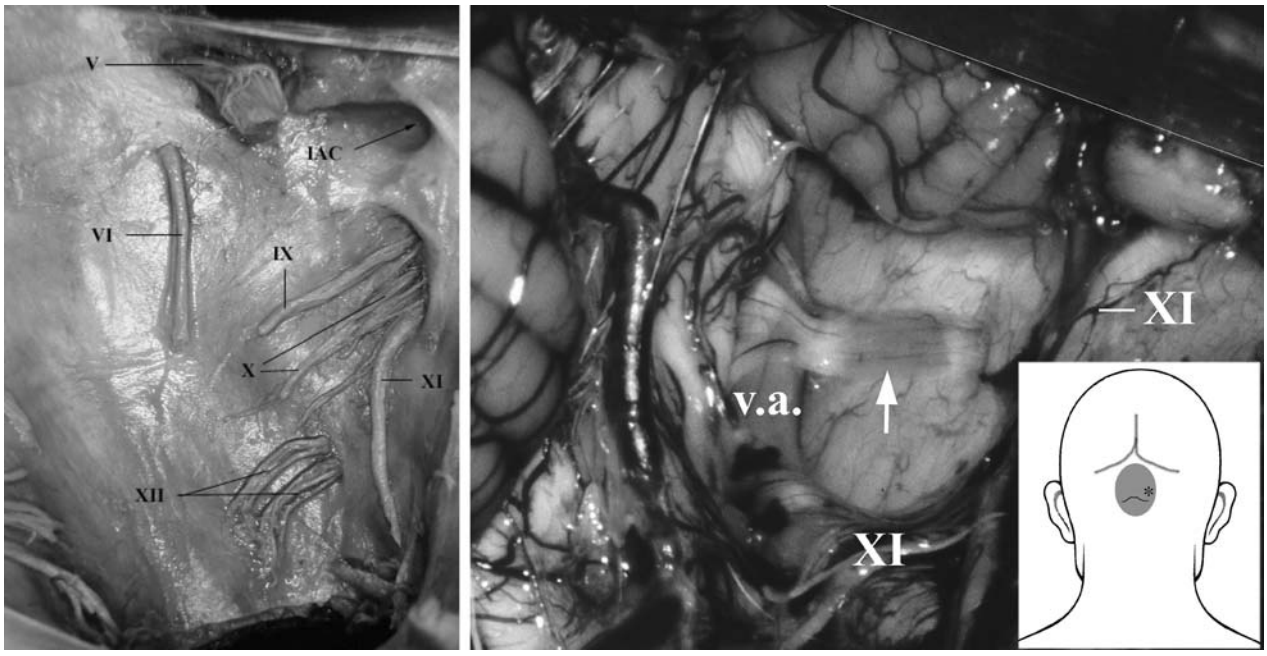

Fig. 1. *Left*: Anatomical dissection of the cranial base detailing the intracranial course of the caudal cranial nerves. *Right*: Intraoperative image of the hypoglossal nerve (*arrow*) crossing the vertebral artery (*v.a.*). Next to the hypoglossal nerve the course of the accessory nerve is visible (*XI.*). Inlet: position of the lateral skull base during the STA approach

[5, 27]. This canal runs anteriorly from an inferomedial to a superolateral direction. It is located inferior, anterior and slight medial to the antero-inferior edge of the jugular bulb [7]. The mean length of the canal varies between 7.8 to 11.2 mm, while the mean breadth of the canal varies from 3.8 to 5 mm [7, 13]. In some cases (28.12%), the hypoglossal canal is divided by a small bony spicule [3]. The mean distance from the midcanal to the carotid artery (at the point where it meets the jugular vein) is 15.3 mm, while the distance from the midcanal to the antero-inferior wall of the jugular bulb is 5.3 mm [7]. Intracranially, the hypoglossal canal and the jugular foramen are separated approximately by a distance of 8 mm [25]. However, only a thin sheet of bone separates them on the external surface of the skull [25]. A meningeal branch of the ascending pharyngeal artery and a small emissary vein (from the inferior petrosal sinus) have been described as canal vascular structures [16, 27]. The canalicular segment of the hypoglossal nerve courses in the hypoglossal canal, where two or three trunks join to form the hypoglossal nerve. This segment of the hypoglossal nerve is surrounded by arachnoid and dura around the first two thirds of its length [24], whereas it is surrounded by a venous plexus in the entire length of the canal [12]. The nerve then has an oblique course in the canal exiting through the inferolateral part of the canal [12]. It bends then anterolaterally toward the IX, X and XI cranial nerves, as they exit the jugular foramen [7]. The extracranial segment of the hypoglossal nerve has a close relationship to the lateral surface of the carotid artery in the neck. Near the anterior belly of the digastric muscle, the nerve turns toward the tongue.

Operative technique

At surgery, bilateral somatosensory evoked potentials (SSEP) and electrophysiological recording of the ipsilateral cranial nerves VII–XII are performed. The patient is placed in the semi-sitting position [authors' preference, although prone (''concorde'') position may be an option]. In the semi-sitting position the patient's legs are raised above of the cardiac level and both knees are slightly flexed. The head is placed in a neutral position and the cervical spine is slightly flexed anteriorly under continuous SSEP monitoring.

Anaesthesiological monitoring includes a central venous catheter placed in the right atrium, continuous invasive blood pressure measurement by radial artery catheter, electrocardiogram, pulse oximetry, capnography with end-tidal CO_2 and a precordial doppler ultrasonography (2.2 MHz) for recognition of any venous air embolism.

A midline vertical skin incision is made from the inion to the second vertebral lamina. A burr hole is performed over the external occipital protuberance. The craniotomy

is directed toward the foramen magnum, which is opened. The posterior arch of the C1 is removed. The dura is opened under the surgical microscope in a Y-like fashion.

As the hypoglossal nerve has a close relationship to the floor of the posterior fossa, hypoglossal schwannomas tend to grow toward the cisterna magna [23]. Thus, they are partially located under the cerebellum, displacing it upwards, while the brainstem is displaced contralaterally (Figs. 2 and 3).

Taking into account the changed local anatomy by the space occupying lesion, which displaces the neurovascular structures in situ, the subtonsillar approach provides an ample and straight corridor, thus allowing tumour removal under excellent control of the surrounding structures. The tumour is initially debulked up to the brainstem, the PICA and the lower cranial nerves. The arachnoid, in a way similar to resection of vestibular schwannomas, is preserved over the surrounding neurovascular structures. After completing resection of tumour within the posterior fossa, the enlarged hypoglossal canal filled with tumour can be seen. The direct angle of view provided by the STA allows further intracanalicular up to extracranial tumour resection. In cases where the tumour is dumbbell shaped with little enlargement of the hypoglossal canal, additional drilling around the canal may provide suitable exposure for removal of the

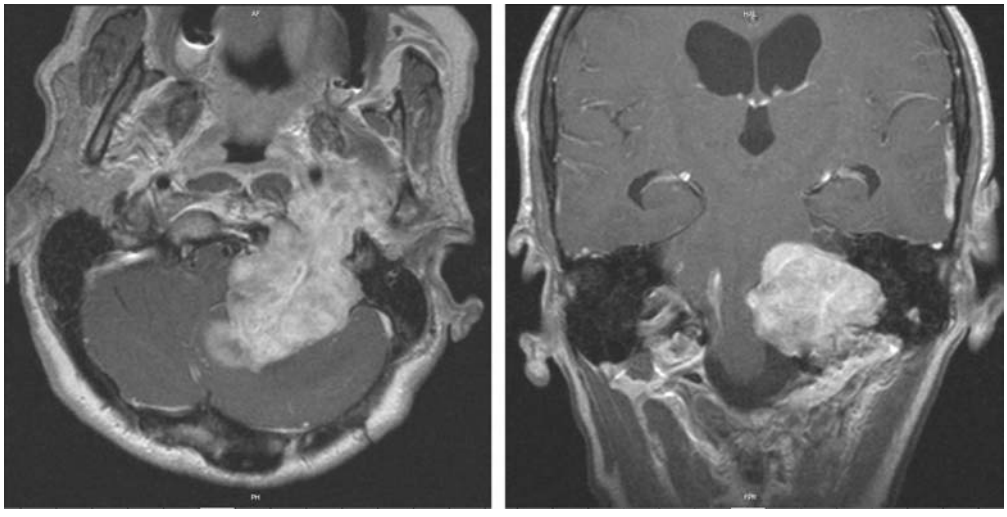

Fig. 2. Axial (*left*) and coronal (*right*) T1-weighted Gd-enhanced MRI demonstrating a large hypoglossal neurinoma with brainstem compression. Note the extracranial extension of the tumor

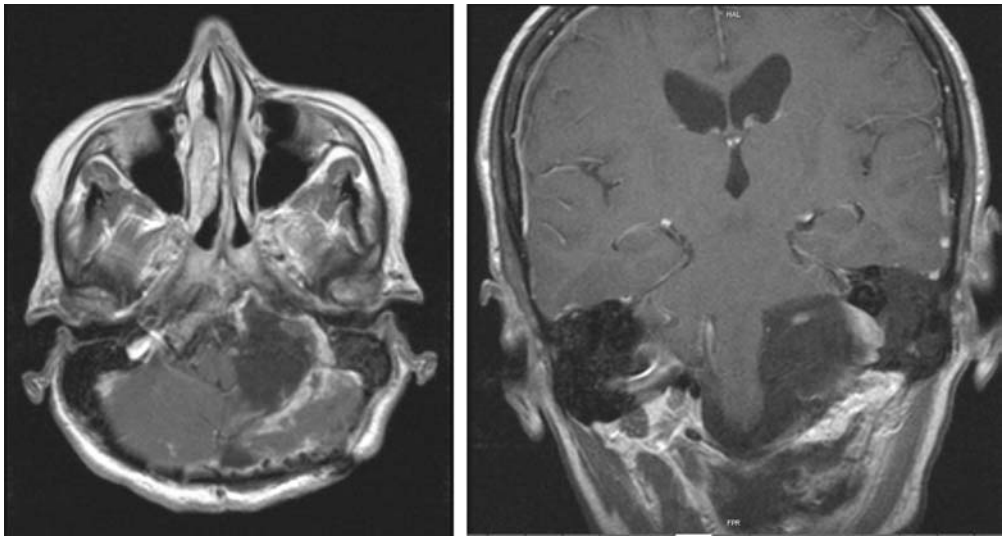

Fig. 3. Early postoperative axial (*left*) and coronal (*right*) T1-weighted Gd-enhanced MRI demonstrating the complete removal of the hypoglossal tumor via the STA approach

extracranial component. After tumour resection is completed, meticulous haemostasis is carried out. Additional jugular vein compression is done in order to rule out any ruptured vein in the semi-sitting position. Dura mater is closed in watertight fashion and the bony flap is replaced. Muscular layers are closed in the standard fashion.

Discussion

Intracranial tumours extending through the hypoglossal canal are rare, and hypoglossal schwannomas are the most commonly reported tumours in this region. They were firstly described by De Martel in 1933 [6]. Ipsilateral tongue palsy and atrophy is the most common clinical presentation in these cases. Patients may also present with jugular foramen syndrome and long tract signs due to brainstem compression [14].

Hypoglossal schwannomas usually arise intracranially and may extend through the hypoglossal canal into the extracranial spaces. A microsurgical approach aiming for complete removal of this benign lesion should preferentially allow excision of both intra- and extracranial lesions in one stage. Moreover, it should provide a suitable surgical exposure and control of the intracranial structures. Several approaches have been used to remove such lesions. Most of these approaches have been adapted from methods used for jugular foramen surgery. Odake *et al.* describes a suboccipital craniectomy with retrolabyrinthine removal of the petrous bone and partial mastoidectomy to excise a hypoglossal schwannoma with extracranial extension [18]. A two-stage removal for the intra- and extracranial parts of the tumour has been suggested by Rachinger *et al.* [19] and Bunc *et al.* [4]. Others using combined extradural-posterior petrous and retrosigmoid suboccipital approaches in treating these lesions [11, 17].

In a 7-year period, Sekhar and co-workers operated upon three cases of hypoglossal tumours. They performed one extreme-lateral approach and one partial-transcondylar approach for predominantly cisternal tumours, while another case was removed by a subtemporal-infratemporal approach [22].

Transcondylar approaches have been favored for removal of hypoglossal schwannomas [8, 23, 24, 26]. Far-lateral approaches (with transcondylar and supracondylar variations) are currently used for approaching the anterolateral margin of the foramen magnum. The transcondylar variant, is directed above the atlanto-occipital joint through the occipital condyle and below the hypoglossal canal to access the lower clivus [20]. The supracondylar approach is directed above the occipital condyle to the hypoglossal canal or both above and below the hypoglossal canal to the lateral side of the clivus [20].

In lesions invading the hypoglossal canal, such as hypoglossal schwannomas, far-lateral transcondylar approaches provide exposure of the intracranial and intracanalicular parts of the tumour as well [8]. Nevertheless, removal of distally located intracanalicular portions of the tumour may require extensive bone resection, whereas removal of extracranial tumour parts requires additional neck dissection. A direct access to the hypoglossal canal is not given, however, because the angle of view is directed from lateral to medial, while the hypoglossal canal courses obliquely – in a medial to lateral direction.

The subtonsillar approach has been proved to give excellent access with a panoramic view to the foramen of Luschka laterally and up to the middle cerebellar peduncle [9]. However the STA has not yet been described for resecting lesions of the hypoglossal canal although the suboccipital midline approach allows tumour removal through a direct angle of view. In addition, the STA takes into consideration the frequent displacement of the anatomy caused by the lesion. Radical resection of the lesion even of its extracranial parts is feasible by a standard and safe craniotomy, without consuming time due to additional bone drilling. Moreover, extradural problems of dealing with the jugular bulb and with the jugular foramen are avoided. The STA is limited however in tumours which extend extracranially too far inferiorly. In these cases additional neck dissection may be necessary.

In conclusion, although the suboccipital midline subtonsillar approach has not been specifically described in the literature yet to treat lesions involving the hypoglossal canal, such as hypoglossal schwannomas, it provides a reasonable route to them. The excellent angle of view provided by this approach may allow radical and safe tumour removal, even with large extracranial components.

References

1. Attallah M, Maier H, Altmannsberger M (1988) [Peripheral neurinoma of the hypoglossal nerve]. HNO 36: 255–256
2. Berger MS, Edwards MS, Bingham WG (1982) Hypoglossal neurilemmoma: case report and review of the literature. Neurosurgery 10: 617–620
3. Bhuller A, Sanudo JR, Choi D, Abrahams PH (1998) Intracranial course and relations of the hypoglossal nerve. An anatomic study. Surg Radiol Anat 20: 109–112
4. Bunc G, Milojkovic V, Kosir G, Kovacic S, Rebol J (1998) Dumb-bell hypoglossal neurinoma with intra- and extracranial paravertebral expansion. Acta Neurochir (Wien) 140: 1209–1210

5. Daniels D, Williams A, Haughton V (1983) Jugular foramen: anatomic and computed tomographic study. AJNR Am J Neuroradiol 4: 1227–1232
6. De Martel T, Subirana A, Guillaune J (1933) [Los tumors de le fosa cerebral posterior: voluminoso neurinoma del hipogloso con desarollo juxta-bulbo-protuberancial]. Operacioncuracion Ars Med 9: 416–419
7. Hadley KS, Shelton C (2004) Infratemporal fossa approach to the hypoglossal canal: practical landmarks for elusive anatomy. Laryngoscope 114: 1648–1651
8. Ho CL, Deruytter MJ (2005) Navigated dorsolateral suboccipital transcondylar (NADOSTA) approach for treatment of hypoglossal schwannoma. Case report and review of the literature. Clin Neurol Neurosurg 107: 236–242
9. Jean WC, Abdel Aziz KM, Keller JT, van Loveren HR (2003) Subtonsillar approach to the foramen of Luschka: an anatomic and clinical study. Neurosurgery 52: 860–866
10. Kachhara R, Nair S, Radhakrishnan VV (1999) Large dumbbell neurinoma of hypoglossal nerve: case report. Br J Neurosurg 13: 338–340
11. Kamitani H, Masuzawa H, Kanazawa I, Kubo T, Tokuyama Y (1994) A combined extradural-posterior petrous and suboccipital approach to the jugular foramen tumours. Acta Neurochir (Wien) 126: 179–184
12. Katsuta T, Matsushima T, Wen HT, Rhoton AL Jr (2000) Trajectory of the hypoglossal nerve in the hypoglossal canal: significance for the transcondylar approach. Neurol Med Chir (Tokyo) 40: 206–209
13. Kirdani MA (1967) The normal hypoglossal canal. Am J Roentgenol Radium Ther Nucl Med 99: 700–704
14. Krauss JK, Bertalanffy H, Schwechheimer K, Muller A, Seeger W (1993) Ventral brain stem schwannoma at the entry zone of the hypoglossal nerve. Neurochirurgia (Stuttg) 36: 66–69
15. Lang J (1983) Clinical anatomy of the head: neurocranium, orbit, craniocervical regions. Springer, Berlin
16. Lang J, Hornung G (1993) [The hypoglossal channel and its contents in the posterolateral access to the petroclival area]. Neurochirurgia (Stuttg) 36: 75–80
17. Myatt HM, Holland NJ, Cheesman AD (1998) A skull base extradural hypoglossal neurilemmoma resected via an extended posterolateral approach. J Laryngol Otol 112: 1052–1057
18. Odake G (1989) Intracranial hypoglossal neurinoma with extracranial extension: review and case report. Neurosurgery 24: 583–587
19. Rachinger J, Fellner FA, Trenkler J (2003) Dumbbell-shaped hypoglossal schwannoma. A case report. Magn Reson Imaging 21: 155–158
20. Rhoton AL Jr (2000) The far-lateral approach and its transcondylar, supracondylar, and paracondylar extensions. Neurosurgery 47: S195–S209
21. Samii M, Matthies C, Tatagiba M (1997) Management of vestibular schwannomas (acoustic neuromas): auditory and facial nerve function after resection of 120 vestibular schwannomas in patients with neurofibromatosis 2. Neurosurgery 40: 696–705
22. Sarma S, Sekhar LN, Schessel DA (2002) Nonvestibular schwannomas of the brain: a 7-year experience. Neurosurgery 50: 437–448
23. Sato M, Kanai N, Fukushima Y, Matsumoto S, Tatsumi C, Kitamura K, Ozaki M, Hayakawa T (1996) Hypoglossal neurinoma extending intra- and extracranially: case report. Surg Neurol 45: 172–175
24. Smith PG, Backer RJ, Kletzker GR, Mishler ET, Loosmore JL, Leonetti JP, Bigelow DC (1995) Surgical management of transcranial hypoglossal schwannomas. Am J Otol 16: 451–456
25. Smoker WR, Harnsberger R, Osborn A (1987) The hypoglossal nerve. Semin Ultrasound CT MR 8: 301–312
26. Spinnato S, Talacchi A, Musumeci A, Turazzi S, Bricolo A (1998) Dumbbell-shaped hypoglossal neurinoma: surgical removal via a dorsolateral transcondylar approach. A case report and review of the literature. Acta Neurochir (Wien) 140: 827–832
27. Voyvodic F, Whyte A, Slavotinek J (1995) The hypoglossal canal: normal MR enhancement pattern. AJNR Am J Neuroradiol 16: 1707–1710
28. Yousry I, Moriggl B, Schmid UD, Wiesman M, Fesl G, Bruckmann H, Naidich TP, Yousry TA (2002) Detailed anatomy of the intracranial segment of the hypoglossal nerve: neurovascular relationships and landmarks on magnetic resonance imaging sequences. J Neurosurg 96: 1113–1122

Comment

This is an article that appeals very much to me because it points out that a straight forward time honoured approach, that is the midline suboccipital subtonsillar approach, is probably to be preferred over the more recently introduced technique's like transcondylar approach and far-lateral approaches to this area. There is no doubt that there is some morbidity involved in very extensive operative procedures like the transcondylar and the far-lateral approach. The simplicity of the midline approach is if the same goal can be reached that is the total removal of the tumour certainly to be preferred over the very elaborate alternative procedures. This reminds me of a PICA aneurysm that I clipped sometime ago by the midline suboccipital approach and which was indeed a very simple and straight forward procedure. A colleague from abroad who watched the procedure was in the beginning surprised that I did not use the far-lateral approach of a variant there of. He was even more surprised when he saw how nicely the aneurysm could be clipped by the of course much more simple and straight forward midline suboccipital approach. There is no doubt that impressive progress is made in the field of skull base surgery however there is a realistic chance that nowadays very extensive approaches through the skull base are used to treat intracranial lesions that can as easily be treated by a simple trephination.

This article merits also publication in Acta Neurochirurgica because a nice anatomical study is performed of which an excellent description is presented in this paper. The clinical case presented very much supports the statement of the authors that this type of lesion that is the hypoglossal schwannoma can be excellently removed through the midline suboccipital subtonsillar approach.

C. A. F. Tulleken
Utrecht

Correspondence: Marcos Tatagiba, Department of Neurosurgery, University of Tuebingen Hoppe-Seyler-Str. 3, 72076 Tuebingen, Germany. e-mail: marcos.tatagiba@med.uni-tuebingen.de